

HUPD-9415  
November, 1994

# The Vertex Corrections in Technicolor Model without Exact Custodial Symmetry

Tadashi YOSHIKAWA

*Department of Physics, Hiroshima University  
1-3-1 Kagamiyama, Higashi-Hiroshima, 724  
Japan*

## Abstract

We discuss the effects of isospin breaking which appear in the vertex corrections for  $Zb\bar{b}$ ,  $Z\tau^+\tau^-$  and  $W\nu\tau$  in a one-family technicolor model without exact custodial symmetry. By means of the effective lagrangian approach we compute the vertex corrections for  $Zb\bar{b}$ ,  $Z\tau\tau$  and  $W\tau\nu$  taking account of the contributions from technivector mesons. If the isospin symmetry in technilepton sector is not exact, technivector mesons contribute to the vertex correction for  $Z\tau\tau$  but such contributions to the correction for  $W\tau\nu$  are absent. If the difference is measured, it is the evidence of the isospin breaking.

In the previous work [1], we constructed the effective Lagrangian for a one-family technicolor model without exact custodial symmetry and discussed the constraints for the oblique corrections. The most distinctive feature from the traditional technicolor theory is the isospin breaking in technilepton sector[2]. In the model [2][1], we find that the constraints for oblique corrections can be satisfied. The effects of the isospin breaking must appear in the vertex correction (non-oblique correction), too. In this letter, we study the vertex correction for  $Zbb$ ,  $Z\tau\tau$  and  $W\tau\nu$  in the technicolor model including isospin breaking with the effective lagrangian. The corrections depend on the decay constant of technipion in each sector ( techniquark sector, technilepton sector ) [3][4][5]. In the model [2][1], one of the isospin breaking effects appears in the difference between the decay constant of the charged technipion and that of neutral technipion in the technilepton sector. From the constraint of the oblique correction  $T$ , the difference between the decay constants of the technipion in technilepton sector must be enough small compared with decay constant in the techniquark sector. Their differences directly appear in the differences between the vertex corrections. The other larger effect of the isospin breaking in the technilepton sector comes from the technivector mesons composed of technileptons. In the model, there are the neutral technivector mesons which contribute to the vertex correction for the  $Z\tau\tau$ , while the charged technivector mesons which should contribute to the correction for the  $W\tau\nu$  are absent. Hence, we may gain some hint about the evidence of isospin breaking in technilepton sector through the difference of the vertex corrections between  $Zbb$  and  $Z\tau\tau$  as well as the difference between  $Z\tau\tau$  and  $W\tau\nu$  in the precision measurements.

The vertex corrections depend on the Extended Technicolor Model ( ETC ). The

Lagrangian <sup>1</sup> which describes the ETC gauge interaction of one family technicolor model between the third family and Technifermion is,

$$\begin{aligned}
\mathcal{L}_{ETC(3-TC)} = & g_{ETC} \xi_L^t \bar{Q}_L^i W_{ETC}^\mu \gamma_\mu q_L^i \\
& + g_{ETC} \xi_R^t \bar{t}_R^i W_{ETC}^\mu \gamma_\mu U_R^i + g_{ETC} \xi_R^b \bar{b}_R^i W_{ETC}^\mu \gamma_\mu D_R^i + h.c. \\
& + g_{ETC} \xi_L^\tau \bar{L}_L W_{ETC}^\mu \gamma_\mu l_L \\
& + g_{ETC} \xi_R^\tau \bar{\tau}_R W_{ETC}^\mu \gamma_\mu E_R + h.c.,
\end{aligned} \tag{1}$$

where  $Q_L^i = (U^i, D^i)_L$ ,  $U_R^i$  and  $D_R^i$  represent techniquarks,  $q_L^i = (t^i, b^i)_L$ ,  $t_R^i$  and  $b_R^i$  represent the third family of quarks and “i” is the color index of QCD.  $L_L = (N, E)_L$ ,  $E_R$  represent the technilepton,  $l_L = (\nu, \tau)_L$  and  $\tau_R$  represent the third family of leptons.  $g_{ETC}$  is a coupling of ETC interaction.  $W_{ETC}$  is an ETC gauge boson which mediates between the third family of ordinary fermions and techni fermions.  $\xi_L^{t(\tau)}$  is a coefficient of left handed coupling and  $\xi_R^{t(b,\tau)}$  is one of right handed coupling. Since the left handed fermion which belongs to  $SU(2)$  doublet, the couplings of up-side and down-side in the doublet are the same as each other.

From eq.(1) the masses of ordinary fermions are given as,

$$m_t \sim \xi_L^t \xi_R^t \frac{g_{ETC}^2}{M_{ETC}^2} < \bar{U}U > \sim \xi_L^t \xi_R^t \frac{g_{ETC}^2}{M_{ETC}^2} 4\pi F_6^3, \tag{2}$$

$$m_b \sim \xi_L^t \xi_R^b \frac{g_{ETC}^2}{M_{ETC}^2} < \bar{D}D > \sim \xi_L^t \xi_R^b \frac{g_{ETC}^2}{M_{ETC}^2} 4\pi F_6^3, \tag{3}$$

$$m_\tau \sim \xi_L^\tau \xi_R^\tau \frac{g_{ETC}^2}{M_{ETC}^2} < \bar{E}E > \sim \xi_L^\tau \xi_R^\tau \frac{g_{ETC}^2}{M_{ETC}^2} 4\pi F_2^3, \tag{4}$$

where  $M_{ETC}$  is the mass of the ETC gauge boson and  $< \bar{Q}Q >$  is the condensation of technifermions.  $F_6$  is the decay constants of technipion in techniquark sector and  $F_2$

---

<sup>1</sup>Similarly some diagonal ETC gauge interactions between the same family also exist [5]. The vertex corrections for this interaction as depicted in Fig.1(b) is exist. The vertex is effectively same with Fig.2, except for the order of technicolor's number  $N_{tc}$ . By mean of  $1/N$  expansion we can ignore this dependence, but if  $N_{TC}$  is small, we need to consider the effects.

is that in technilepton sector. Here we used the relation of naive dimensional analysis  $\langle \bar{Q}Q \rangle \sim 4\pi F_Q^3$  [6].

Now, the vertex correction under consideration is shown in Fig.1(a). Because we assume that the ETC gauge boson is much heavier than the weak gauge boson, we can shrink the gauge propagator as shown in Fig.2. The ETC interaction in eq.(1) becomes the following effective four-fermi interaction after Fierz transformation,

$$\begin{aligned} \mathcal{L}_{int} = & - \frac{1}{2} \xi_L^t{}^2 \frac{g_{ETC}^2}{M_{ETC}^2} (\bar{q}_L \gamma^\mu \tau^A q_L) (\bar{Q}_L \gamma_\mu \tau^A Q_L) \\ & - \frac{1}{2} \xi_L^\tau{}^2 \frac{g_{ETC}^2}{M_{ETC}^2} (\bar{l}_L \gamma^\mu \tau^A l_L) (\bar{L}_L \gamma_\mu \tau^A L_L). \end{aligned} \quad (5)$$

Then we replace the left handed technifermion current by chiral current [7][3][4][5], that is the Noether current for  $SU(2)_L$  symmetry in our effective Lagrangian<sup>2</sup> [1]. With the replacement, we obtain,

$$\begin{aligned} \mathcal{L}_{int} = & - \frac{1}{2} \xi_L^t{}^2 \frac{g_{ETC}^2}{M_{ETC}^2} [\bar{q}_L \gamma^\mu \{ \\ & - F_6^2 \frac{\sqrt{3}}{2} (gW_\mu^3 - g'B_\mu) \frac{\tau^3}{\sqrt{3}} - F_6^2 \frac{\sqrt{3}}{2} \sum_{a=1}^2 (gW_\mu^a) \frac{\tau^a}{\sqrt{3}} \\ & + \frac{M_{V6}^2}{G_6} [\rho_{6\mu}^3 - \frac{\sqrt{3}}{2G_6} (gW_\mu^3 + g'B_\mu)] \frac{\tau^3}{\sqrt{3}} \\ & + \frac{M_{\omega 6}^2}{G_{6\omega}} [\omega_{6\mu} - \frac{\sqrt{3}}{2G_{6\omega}} 2Y_{Lq} g'B_\mu] \frac{Y_{Lq}}{\sqrt{3}} \} q_L] \\ & - \frac{1}{2} \xi_L^\tau{}^2 \frac{g_{ETC}^2}{M_{ETC}^2} [\bar{l}_L \gamma^\mu \{ \\ & - F_2^2 \frac{1}{2} (gW_\mu^3 - g'B_\mu) \tau^3 - F_L^2 \frac{1}{2} \sum_{a=1}^2 (gW_\mu^a) \tau^a \\ & + \frac{M_{V2}^2}{G_2} [\rho_{2\mu}^3 - \frac{1}{2G_2} (gW_\mu^3 + g'B_\mu)] \tau^3 \\ & + \frac{M_{\omega 2}^2}{G_{2\omega}} [\omega_{2\mu} - \frac{1}{2G_{2\omega}} 2Y_{Ll} g'B_\mu] Y_{Ll} \\ & + \frac{\beta_V}{2G_2} [\omega_{2\mu} - \frac{1}{2G_{2\omega}} 2Y_{Ll} g'B_\mu] \tau^3 \end{aligned}$$

---

<sup>2</sup>The effective lagrangian include both the technivector mesons and the techniaxialvector mesons in the techniquark sector and the neutral technivector mesons and an exsotic charged left-handed meson in the technilepton sector. Here, for simplicity, we assume that the masses of the axialvector mesons and the left-handed meson are much larger than them of the other vector meson in each sector. Then, we can ignore the effects of their technimesons. Indeed, we have known that the contributions of the axialvector mesons for  $S$  parameter are smaller than them of the vector mesons in the previous work [1].

$$+ \frac{\beta_V}{2G_{2\omega}}[\rho_{2\mu}^3 - \frac{1}{2G_2}(gW_\mu^3 + g'B_\mu)]Y_{Ll}\}l_L], \quad (6)$$

where, we followed the same notation as that used in ref.[1].  $\rho$  and  $\omega$  are technivector mesons which are the bound states of technifermion.  $M_V$  and  $M_\omega$  are their masses. In the technilepton sector, because of the presence of the isospin breaking terms, there are the mixings between neutral vectormesons, techni- $\rho$  and techni- $\omega$ . Therefore we must diagonalize the mixing when we compute the effects of the technivector meson in technilepton sector.

With eq.( 6 ), the vertex corrections are the following,

$$\delta g_L^{Zb\bar{b}} = \frac{1}{4}\xi_L^t \frac{g_{ETC}^2}{M_{ETC}^2} F_6^2 \sqrt{g^2 + g'^2} + \delta \bar{g}_L^{Zb\bar{b}}, \quad (7)$$

$$\delta g_L^{Z\tau^+\tau^-} = \frac{1}{4}\xi_L^\tau \frac{g_{ETC}^2}{M_{ETC}^2} F_2^2 \sqrt{g^2 + g'^2} + \delta \bar{g}_L^{Z\tau^+\tau^-}, \quad (8)$$

$$\delta g_L^{W\tau\nu} = -\frac{1}{2\sqrt{2}}\xi_L^\tau \frac{g_{ETC}^2}{M_{ETC}^2} F_L^2 g, \quad (9)$$

where  $\delta \bar{g}_L^{Zb\bar{b}}$  and  $\delta \bar{g}_L^{Z\tau\tau}$  are the corrections from the effect from the technivector mesons in each sector as shown in Fig.3. We assume that technivector mesons in techniquark sector can be ignored when their masses are very heavy,  $M_{V6}, M_{\omega6} \sim 1$  TeV, compared with weak gauge boson masses. On the other hand, it is expected that the masses of the technivector mesons in the technilepton sector are lighter than those in the techniquark sector in this model [2], because the pion decay constants in the technilepton sector are much smaller than those in the techniquark sector. Then the contribution of these light technivector mesons may be large and can not be ignored. Therefore we also compute the effects of technivector mesons in technilepton sector. Substitutiong for  $g_{ETC}^2/M_{ETC}^2$  from eq.(3) in eqs.(7)-(9), we find

$$\delta g_L^{Zb\bar{b}} = \frac{1}{4} \frac{\xi_L^t}{\xi_R^t} \frac{m_t}{4\pi F_6} \sqrt{g^2 + g'^2}, \quad (10)$$

$$\delta g_L^{Z\tau^+\tau^-} = \frac{1}{4} \frac{\xi_L^{\tau^2}}{\xi_L^t \xi_R^t} m_t \frac{F_2^2}{4\pi F_6^3} \sqrt{g^2 + g'^2} + \delta \bar{g}_L^{Z\tau\tau}, \quad (11)$$

$$\delta g_L^{W\tau\nu} = -\frac{1}{2\sqrt{2}} \frac{\xi_L^{\tau^2}}{\xi_L^t \xi_R^t} m_t \frac{F_L^2}{4\pi F_6^3} g. \quad (12)$$

The correction from the vectormesons is,

$$\begin{aligned} \delta \bar{g}_L^{Z\tau\tau} = \frac{1}{4} \xi_L^{\tau^2} \frac{g_{ETC}^2}{M_{ETC}^2} \quad & \{ \quad \frac{1}{G_2^2} [\frac{M_\rho^2}{2} A_\rho^2 \frac{p^2}{p^2 - M_\rho^2} + \frac{M_\omega^2}{2} A_\omega^2 \frac{p^2}{p^2 - M_\omega^2}] \frac{g^2 - g'^2}{\sqrt{g^2 + g'^2}} \\ & + \frac{1}{G_{2\omega}^2} [\frac{M_\rho^2}{2} B_\rho^2 \frac{p^2}{p^2 - M_\rho^2} + \frac{M_\omega^2}{2} B_\omega^2 \frac{p^2}{p^2 - M_\omega^2}] \frac{2g'^2}{\sqrt{g^2 + g'^2}} \\ & + \frac{1}{G_2 G_{2\omega}} [\frac{M_\rho^2}{2} A_\rho B_\rho \frac{p^2}{p^2 - M_\rho^2} + \frac{M_\omega^2}{2} A_\omega B_\omega \frac{p^2}{p^2 - M_\omega^2}] \sqrt{g^2 + g'^2} \}, \end{aligned} \quad (13)$$

with

$$A_\rho = c_V(1 - \alpha_V)^{\frac{1}{2}} - s_V(1 + \alpha_V)^{\frac{1}{2}}, \quad (14)$$

$$B_\rho = -c_V(1 - \alpha_V)^{\frac{1}{2}} - s_V(1 + \alpha_V)^{\frac{1}{2}}, \quad (15)$$

$$A_\omega = c_V(1 + \alpha_V)^{\frac{1}{2}} + s_V(1 - \alpha_V)^{\frac{1}{2}}, \quad (16)$$

$$B_\omega = c_V(1 + \alpha_V)^{\frac{1}{2}} - s_V(1 - \alpha_V)^{\frac{1}{2}}, \quad (17)$$

where we followed the notation of ref.[1].  $\alpha_V$  is a parameter which indicates the isospin breaking (the mixing between techni- $\rho$  and techni- $\omega$  in their kinetic terms of them), and  $c_V$  and  $s_V$  represent  $\cos\theta_V$ ,  $\sin\theta_V$ , where  $\theta_V$  is the mixing angle to diagonalize the  $\rho - \omega$  mixing terms.

Now, we impose the constraints for the decay constants of technipion and consider some conditions which satisfy them. In the present model, in order to satisfy the constraint of the oblique correction, the pion decay constant in the technilepton sector must be much smaller than the decay constant in techniquark sector. We search the values of decay constant which satisfy the conditions, and compute the vertex corrections for  $Zbb$ ,  $Z\tau\tau$

and  $W\tau\nu$ . First, we can obtain the constraints from the relation between weak-gauge boson masses and the decay constants. In a one-family technicolor model with custodial symmetry the constraint is  $4F_\pi^2 \simeq (250)^2$ . On the other hand, because in the present model the decay constant in the technilepton sector are different from that in the techniquark sector, the constraint is

$$3F_6^2 + F_2^2 \simeq (250)^2. \quad (18)$$

The second constraint is obtained from  $T$  parameter [8] which indicates the breaking of custodial symmetry. The condition is obtained from the constraint of  $T$  parameter [8]. The upper bound of  $T$  parameter is

$$T < 0.5. \quad (19)$$

$T$  parameter is given by [1],

$$\alpha T = \frac{F_L^2 - F_2^2}{3F_6^2 + F_2^2}.$$

Combining eq.(18) with eq.(19), we obtain the constraint between  $F_L$  and  $F_2$ ,

$$F_L^2 - F_2^2 < 300. \quad (20)$$

The last constraint is obtained from the ratios of masses of ordinary fermions  $m_\tau : m_b : m_t \sim 1 : 3 : 100$ . From mass formulae in eqs.(3) - (5), we obtain

$$\xi_L^\tau \xi_R^\tau F_2^3 : \xi_L^t \xi_R^b F_6^3 : \xi_L^t \xi_R^t F_6^3 \sim 1 : 3 : 100. \quad (21)$$

To determine the decay constants, we need to make some assumptions on the coupling constants  $\xi$ s. Here we assume that the difference between the masses of the ordinary quark and the lepton comes from the differences of the decay constants of technipion in each sector. There are two cases roughly. One of them is that the difference of the decay

constants is due to the difference between the masses of the up-type quark ( $t$ ) and the lepton ( $\tau$ ). The other is that the difference is due to the difference between the down-type quark ( $b$ ) and the lepton. Correspondingly, we assume the relations among the couplings  $\xi$ s, i.e., (A)  $\xi_L^\tau \xi_R^\tau = \xi_L^t \xi_R^t$  and (B)  $\xi_L^\tau \xi_R^\tau = \xi_L^t \xi_R^b$ . For both cases, we can determine the values of the pion decay constants with the constraints on eq.(18), eq.(20) and eq.(21) .

$$(A) \quad \xi_L^\tau \xi_R^\tau = \xi_L^t \xi_R^t: \quad F_6 = 143 GeV, F_2 = 31 GeV, F_L = 35 GeV$$

$$(B) \quad \xi_L^\tau \xi_R^\tau = \xi_L^t \xi_R^b: \quad F_6 = 135 GeV, F_2 = 90 GeV, F_L = 92 GeV$$

In both cases, we compute the vertex correction for  $Zb\bar{b}$ ,  $Z\tau\tau$  and  $W\tau\nu$  without including the correction due to the technivector mesons ( $\delta\bar{g}$ ) as shown Table 1, Table 2 and Table 3 respectively. For comparison, as case (C), we show the vertex correction for the case when the decay constants in technilepton and techniquark sector are degenerate. Here, we find that the contributions of technipion for their vertex corrections ( $\delta g - \delta\bar{g}$ ) become large, as the difference between the decay constants in the techniquark sector and the technilepton sector is becoming smaller.

Next, we consider the correction,  $\delta\bar{g}_L^{Z\tau\tau}$ , which comes from the technivector mesons in the technilepton sector. For simplicity, we put  $\alpha_V \sim 1$ ,  $c_V \sim 1$  and  $s_V \sim 0$  in the factors in eqs.(14)-(17), and substitute for  $\frac{g_{ETC}^2}{M_{ETC}^2}$  from eq.(2) in eq.(13). Then eq.(13) becomes,

$$\begin{aligned} \delta\bar{g}_L^{Z\tau\tau} = \frac{1}{4} \frac{\xi_L^{\tau^2}}{\xi_L^t \xi_R^t} \frac{m_t}{4\pi F_6^3} \{ & \frac{1}{G_2^2} [M_\omega^2 \frac{p^2}{p^2 - M_\omega^2}] \frac{g^2 - g'^2}{\sqrt{g^2 + g'^2}} \\ & + \frac{1}{G_{2\omega}^2} [M_\omega^2 \frac{p^2}{p^2 - M_\omega^2}] \frac{2g'^2}{\sqrt{g^2 + g'^2}} \\ & + \frac{1}{G_2 G_{2\omega}} [M_\omega^2 \frac{p^2}{p^2 - M_\omega^2}] \sqrt{g^2 + g'^2} \} \end{aligned} \quad (22)$$

Here at the scale of  $p^2 \simeq M_Z^2$ , we find that the contribution becomes large in the following cases. (1) The technivector meson's mass is close to the gauge-boson's mass. (2) The



couplings  $G_2$  and  $G_{2\omega}$  are becoming smaller. Because the smaller values for  $G_2$  and  $G_{2\omega}$  are favored to satisfy the constraint of the oblique correction  $S$  [1], the contribution from the technivector mesons will also be large. In Fig.4, we present the behavior of  $\delta g_L^{Z\tau\tau}$  including the contribution of the technivector mesons  $\delta \bar{g}_L^{Z\tau\tau}$  as a function of  $M_\omega$  for several sets of values of  $G_2$  and  $G_{2\omega}$ . In the previous work [1], we find that the value of  $G_6^2$  is 31.5 when the custodial symmetry for a doublet is exact. The upper bound of  $G_{2\omega}$  [1] which makes  $S$  to be negative is,

$$G_{2\omega} < \frac{G_6}{\sqrt{3}} \sim \frac{5.61}{\sqrt{3}} \sim 3.24. \quad (23)$$

Therefore we plot the graph in the following three cases in Fig.4.

- (1)  $G_2, G_{2\omega} = 5.61$
- (2)  $G_2, G_{2\omega} = 3.24$  (  $S = 0$  )
- (3)  $G_2, G_{2\omega} = 2$  (  $S = -2$  )

The case(1) is one with positive  $S$  like the traditional technicolor model with custodial symmetry. The case(2) is one with  $S = 0$ , and the case(3) is an extreme case with  $S = -2$ . Here we obtain the suppression on the vertex correction for  $Z\tau\tau$  due to the vector meson when  $S$  is negative (Fig.4). However, the correction for  $W\tau\nu$  does not depend on the effects of the technivector mesons, because there are not such charged technivector mesons in the present model. We find that the difference between the vertex corrections of  $Z\tau\tau$  and  $W\tau\nu$  in terms of the contribution from the technivector mesons appear. In other words, the difference will be the evidence of the isospin breaking in technilepton sector.

In this letter we have described the vertex correction of  $Zb\bar{b}$ ,  $Z\tau\tau$  and  $W\nu\tau$  in the one family extended technicolor model without exact custodial symmetry. The values of the corrections can not be determined precisely, since the corrections include a few unknown parameters  $\xi$ s. The corrections which are obtained in this letter is much larger

than those in one doublet model. If we suitably choose each unknown parameter  $\xi$ , we will be able to obtain the vertex corrections which satisfy the constraint from the experiment. When  $\xi = 1$ , the vertex corrections are so large that this model is ruled out. Then, in order to reduce the values in this case, we may have to consider the other ETC model or walking technicolor. However, we find that if the difference between the vertex corrections for  $Z\tau\tau$  and  $W\tau\nu$  is measured in experiment, it is the evidence of the isospin breaking in the technilepton sector. It comes from not only the difference between the decay constants but a large contribution to  $Z\tau\tau$  vertex due to the technivector mesons. The contributions of the vector mesons for  $Z\tau\tau$  reduce the value which takes account of only technipion contribution (the first term of the eq.(11)). The vertex correction for the  $Z\tau\tau$  can be negative due to this effect. However, the contribution of the technivector mesons are absent in the vertex correction for the  $W\tau\nu$ . Hence, the difference between the corrections for the  $Z\tau\tau$  and the  $W\tau\nu$  appear. We expect that in the near future the precession measurements (in LEP, JLC etc.) of the vertex corrections of  $W\tau\nu$  will determine whether the isospin of technilepton sector breaks or not.

## Acknowledgement

We would like to thank T.Morozumi and L.T.Handoko for discussion and reading the manuscript.

## References

- [1] T. Yoshikawa, H. Takata and T. Morozumi, *Prog. Theor. Phys.* **92** (1994) 353.
- [2] T. Appelquist and J. Terning, *Phys. Lett.* **B315** (1993) 139.
- [3] R. S. Chivukula, E. B. Selipsky and E. H. Simmons, *Phys. Rev. Lett.* **69** (1992) 575 .

- [4] R. S. Chivukula, E. Gates, E. H. Simmons and J. Terning, *Phys. Lett.* **B311** (1993) 157 ;  
N. Evans *Phys. Lett.* **B331** (1994) 378.
- [5] N. Kitazawa, *Phys. Lett.* **B313** (1993) 393.
- [6] A. Manohar and H. Georgi, *Nucl. Phys.* **B234** (1984) 189.
- [7] H. Georgi, *Weak Interactions and Modern Particle Theory* (Benjamin-Cummings, Menlo Park, 1984), p77.
- [8] B. Holdom and J. Terning, *Phys. Lett.* **B247** (1990) 88 ;  
M. Golden and L. Randall, *Nucl. Phys.* **B361** (1991) 3 ;  
M. E. Peskin and T. Takeuchi, *Phys. Rev. Lett.* **65** (1990) 964 ; *Phys. Rev.* **D46** (1992) 381.

## Table Captions

- **Table 1** : The value of the vertex correction of  $Zb\bar{b}$  and an amount of shifting the  $Zb\bar{b}$  width from the standard model in a one-family technicolor model without exact custodial symmetry for each cases.
- **Table 2** : The value of the vertex correction of  $Z\tau\tau$  and an amount of shifting the  $Z\tau\tau$  width from the standard model except for the contribution from the technivector mesons in a one-family technicolor model without exact custodial symmetry for each cases.
- **Table 3** : The value of the vertex correction of  $W\tau\nu$  and an amount of shifting the  $W\tau\nu$  width from the standard model in a one-family technicolor model without exact custodial symmetry for each cases.

## Figure Captions

- **Fig. 1(a)** : The Feynman daigram for the contribution to the vertex correction according to side way ETC gauge interaction.
- **Fig. 1(b)** : The Feynman diagram for the contribution to the vertex correction according to diagonal ETC gauge interaction.
- **Fig. 2** : The Feynman diagram in which the ETC gauge boson propagators are shrunk in Fig.1(a) and Fig.1(b).
- **Fig. 3** : The Feynman diagram to compute the vertex correction by effective lagrangian approach. The first shows the effects of thechnivector mesons. The second shows the effects of the thecnipion.

- **Fig. 4 (A) (B)** : In (A) (  $F_6, F_2$  ) = ( 143GeV,31GeV ) and (B) (  $F_6, F_2$  ) = ( 135GeV,90GeV ), plotting the  $\delta g_L^{Z\tau\tau}$  as a function of  $M_\omega$  for the each casees, (1)  $G_{2\omega} = 5.61$  with a dashline, (2)  $G_{2\omega} = 3.24$  ( $S = 0$ ) with a thickline and (3)  $G_{2\omega} = 2$  ( $S = -2$ ) with a thinline.

	$(F_6, F_2)$	$\delta g_L^{Zbb}$	$\frac{\delta\Gamma}{\Gamma}$
(A)	$(143GeV, 31GeV)$	$0.0181(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$	$-11\%(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$
(B)	$(135GeV, 90GeV)$	$0.0192(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$	$-11\%(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$
(C)	$(125GeV, 125GeV)$	$0.0207(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$	$-13\%(\frac{m_t}{175})\frac{\xi_L^t}{\xi_B^t}$

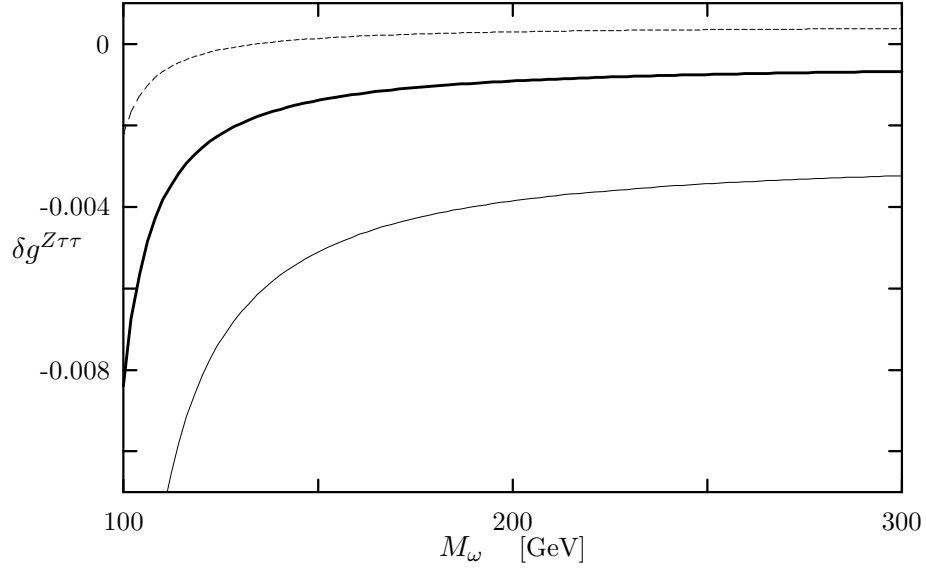
Table 1

	$(F_6, F_2)$	$\delta g_L^{Z\tau^+\tau^-} - \delta \bar{g}_L^{Z\tau\tau}$	$\frac{\delta\Gamma}{\Gamma}$
(A)	$(143GeV, 31GeV)$	$0.0009(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-0.5\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$
(B)	$(135GeV, 90GeV)$	$0.0085(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-4.9\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$
(C)	$(125GeV, 125GeV)$	$0.0207(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-12\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$

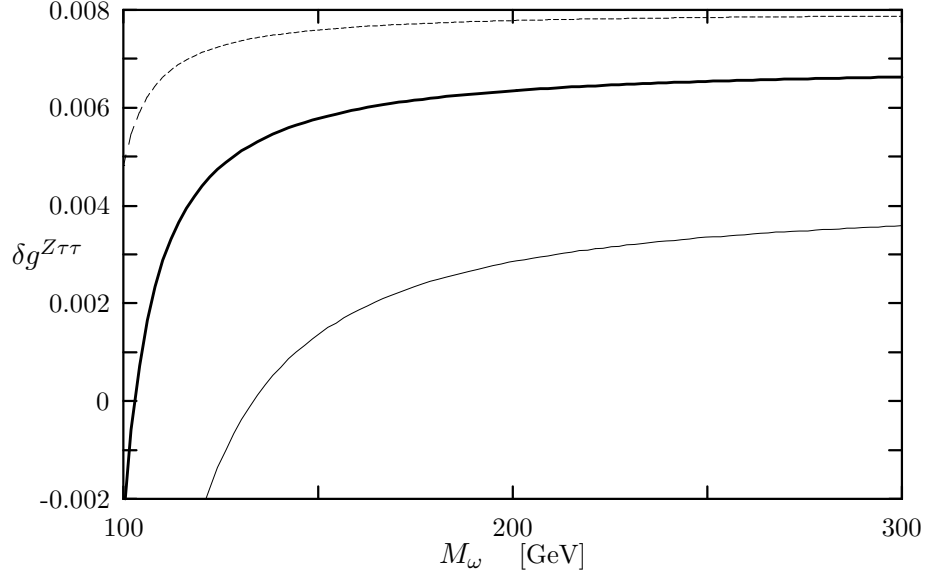
Table 2

	$(F_6, F_L)$	$\delta g_L^{W\tau\nu_\tau}$	$\frac{\delta\Gamma}{\Gamma}$
(A)	$(143GeV, 35GeV)$	$-0.0015(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-0.5\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$
(B)	$(135GeV, 92GeV)$	$-0.0126(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-3.8\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$
(C)	$(125GeV, 125GeV)$	$-0.0292(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$	$-9\%(\frac{m_t}{175})\frac{\xi_L^{\tau^2}}{\xi_L^t \xi_B^t}$

Table 3



**Fig.4 (a)**



**Fig.4 (b)**

This figure "fig1-1.png" is available in "png" format from:

<http://arXiv.org/ps/hep-ph/9411280v1>



This figure "fig1-2.png" is available in "png" format from:

<http://arXiv.org/ps/hep-ph/9411280v1>

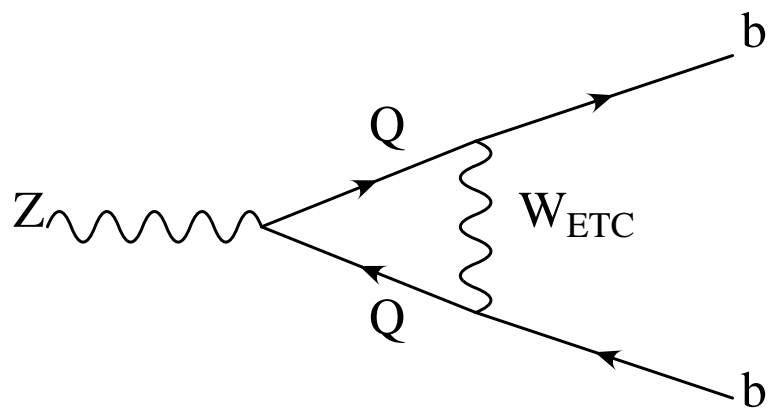


Fig.1(a)

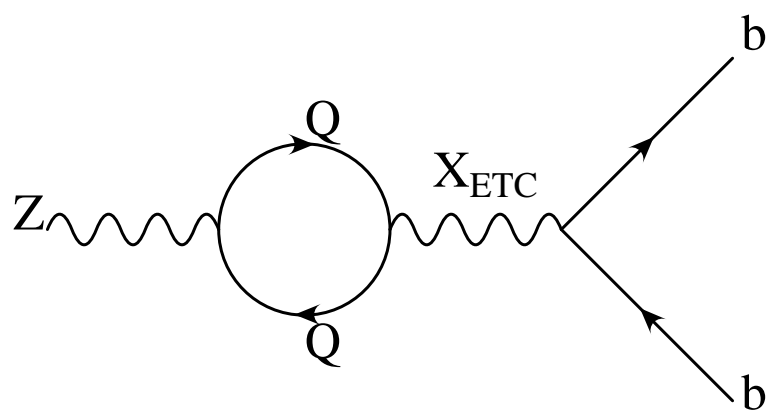


Fig.1(b)

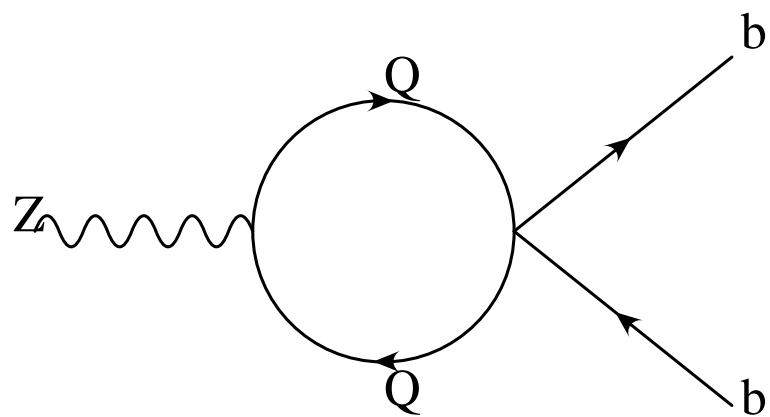


Fig.2

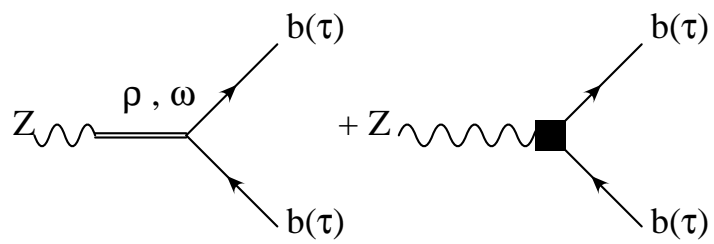


Fig.3